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ABSTRACT

The results of a survey of elementary school teachers in North Dakota are reported, in a search for answers to two questions: (1) What manipulative materials are currently being used for mathematics instruction, and to what extent; and (2) Who is using them? A brief review of previous research indicated that the use of manipulative materials is more effective than non-use. A questionnaire was sent to principals in each of the three levels of elementary schools in North Dakota; 116 schools (79%) returned 989 completed questionnaires (47%). Data on teacher characteristics, the extent of use of materials, attitudes toward materials, and relationships among variables are reported. Manipulative materials were used at all grade levels (K-6); 14 materials were used at all grade levels 1-6, with two not used in kindergarten. Almost half (48%) of the respondents indicated "little" use of materials, while 7% indicated "extensive" use. Metric materials were most widely used, followed by counting chips and bundles of sticks. Teachers believed that slow learners profit more from using materials (94%) than average (77%) or fast learners (41%). Forty percent felt that materials were "always needed" (K-12). Correlations among selected variables are presented, followed by discussion and recommendations. (MS)

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AN ANALYSIS OF THE USE OF MATH MANIPULATIVE MATERIALS IN NORTH DAKOTA

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AN ANALYSIS OF THE USE OF MATH MANIPULATIVE MATERIALS IN NORTH DAKOTA

by

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Bureau of Educational Research and Services

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Grand Forks, North Dakota

August 1977

FOREWORD

The Bureau of Educational Research and Services, for the second successive year, has supported faculty research during a portion of the University of North Dakota Summer Session. This publication represents the research effort of Dr. Ronald Kutz, a member of the faculty in the Center for Teaching and Learning at the University of North Dakota.

In addition, this publication becomes another in the series of monographs being made available by the Bureau of Educational Research and Services, as a part of the on-going effort to make current research more readily accessible to interested persons both in and out of the education profession.

Dr. Kutz has surveyed several hundred elementary classroom teachers in North Dakota regarding the use of math manipulatives in their teaching of mathematics. It is certainly an extensive survey, and the findings are of more than a passing interest to elementary mathematics educators--not only in North Dakota, but across the nation.

Appreciation for the completion of this research effort is extended to all who took the necessary time to respond to the mailed questionnaire, to those who assisted in data analysis and to Mrs. Ruth Berger for typing the final manuscript and readying it for ultimate publication.

Larry L. Smiley
Director
Bureau of Educational Research and Services

August, 1977

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The author owes thanks to many people who assisted in this effort. First and foremost, thanks are due to the teachers of North Dakota who completed the questionnaire and to their principals who distributed, collected and returned them. Without their support, there would have been no study. Recognition is also due to Ms. Harriet Kinghorn, Mr. David Moen, Dr. Glenn Prigge, Dr. Ken Vos, Dr. Jim Babb, and Dr. Jane Gawronski, all of whom previewed the questionnaire, to Dr. John Williams, who assisted with the computer and statistical analysis, to Dr. Larry Smiley, Dr. Erv Behsman, and the University of North Dakota Bureau of Educational Research and Services, who provided the financial support necessary for the project, to Ms. Becki Anderson, who helped code the questionnaire onto computer forms, to my wife, Dory, who helped find my misspellings and awkward sentences, and to Mrs. Ruth Berger who typed the monograph from a none too neat manuscript.

I. INTRODUCTION

The work of Jean Piaget has had a profound effect on mathematics education in the last decade. Piaget hypothesized that is was the physical interaction of the child and his environment that produced mental growth and understanding. Mathematics educators, led by Zoltan Dienes and Caleb Gattegno, have developed numerous manipulative materials that embody mathematical concepts and enable the child to physically interact with the mathematical models. In the late 1960's and early 1970's, these materials became fairly widely available, and most teacher training programs have been including use of manipulative materials as part of the mathematics training program. Virtually all mathematics "methods" texts include use of manipulative materials, and much inservice work and professional journal space has been devoted to these materials.

Still, use of mathematics manipulative materials designed for concept development appears to have remained fairly limited. Most concepts are introduced at the pictorial or abstract--rather than concrete--levels, or are introduced by use of materials manipulated by the teacher rather than the students. While this may be unfortunate, it is certainly not surprising. A number of factors combine to explain this circumstance; among them:

1. Few, if any, currently existing teachers have been taught with math manipulative materials at the elementary school level. Hence, they have no first hand experience with that style of teaching. Those who have been teaching for more than 6-10 years will not even have been exposed to these materials in their teacher training programs.

2. The textbook is the main teaching aid, and no major text requires (and few even encourage) the teacher to use math manipulative materials.

3. Materials are generally expensive, budgets are limited.

The perceived discrepancy between the theoretical need for manipulative experiences and common teaching practices focusing on the textbooks led to this study. Specifically, answers were sought for two questions:

1. What math manipulative materials are currently being used in North Dakota elementary school classrooms, and to what extent?

2. Who is using them?

The first question was the easier to approach, particularly since no attempt was made to answer "How are they being used?", or "Is this use effective?". The second question was more difficult, and, in effect, was approached as an attempt to identify characteristics of the sample teachers that might differentiate those who use math manipulative materials from those who do not. A discussion of the questionnaire designed to answer these questions is included later.

Is use of math manipulative materials really important? As with any nontrivial question concerning education, definitive answers are difficult to obtain. Clearly, it is possible to find effective teachers who do not use the materials, and ineffective teachers who do. To attempt a controlled research study on the question, it is necessary to narrowly define "effective" and to narrowly proscribe use of materials which, of course, produces narrow results, easily debatable by both sides. Educators schooled in Piaget's develop-

mental theory generally support use of math manipulative materials as an essential structuring and enriching of the child's environment (c.f. Copeland [5], Elkind [9], Reys [22], Payne [15], Dienes [7]). It is the author's bias that, other things being equal, use of math manipulative materials is more effective than non-use, particularly in concept development and attitude.

The research that does exist tends to support this view. The 1973 yearbook of the National Countil of Teachers of Mathematics, Instructional Aids in Mathematics, states in its chapter on "Manipulative Devices in Elementary School Mathematics":

> Some support and direction for the use of manipulative devices can be found in various research projects. However, much of the research evidence is inconclusive. Sole found that using a variety of materials does not produce better results than using a single device if both procedures are used for the same amount of time (27). If more time is spent, achievement improves, regardless of what or how many materials are used....
>
> (Harvin)...established through an extensive questionnaire that frequency of use of manipulative materials appears to be a contributing factor in achievement in elementary mathematics. (12)...
>
> (Edison's) study showed that most effective results are obtained by placing major emphasis on the use of devices to obtain data rather than for supplementary activities. He cautions users to remember that aids never teach mathematics and that the role of the teacher is paramount. (8) Another warning is given to teachers using manipulative devices by Sole when he states that manipulation of any device must not be confused with the learning of mathematics (27). Mathematics is made up of ideas--not materials; it can be illustrated with devices and has application to many concrete situations, but it must be understood as a system of ideas.
>
> The findings of two researchers, Swick and Spross, give strong support to the desirability of using multisensory aids in teaching both computation and reasoning (33; 28). In addition, the use of aids and devices was found to improve the attitude of second- and third-graders toward mathematics.

> Adkins and Suddeth concluded that there seems to be a tendency to use more instructional materials in the primary grades for the purpose of discovering relationships, for motivation, and for influencing attitude (1; 29).
>
> This research gives credence to the hypothesis that manipulative devices are useful in the attainment of the goals of mathematics instruction (13).

In a review of annotations included in "Research on Mathematics Education (K-12) Reported in 1973-4-5", Suydam and Weaver (30, 31, 32), the author found 19 studies concerning the effectiveness of math manipulative material use (out of 287 journal articles and 829 dissertation abstracts reviewed). Of those 19, fifteen found some significant differences in favor of a group using math manipulative materials (2, 3, 4, 6, 10, 11, 14, 16, 18, 20, 21, 24, 34, 36, 37) two found mixed results (some in favor of each group), (25, 35) and two found no differences (23, 26). Although each individual study covers a fairly narrow set of experiences and situations, in totality they can be taken to support a continued expansion of use of math manipulative materials. It was the author's hope that this study might indicate some directions in which to proceed.

II. PROCEDURES

A questionnaire was developed to determine use of math manipulative materials and related teacher characteristics and attitudes; a copy of the questionnaire and transmitted letter is included as Appendix A. The questions fall roughly into three categories. Questions 1 through 8, 15, 19 and 21 obtain information about the teacher, including educational background, current class setting, attitude toward math and the textbook, and preparation with respect

to math manipulative materials. Questions 9 through 13 obtain information about which math manipulative materials are used, how extensively they are used, and sources. Questions 14, 16, 17, 18, and 20 obtain information about the teacher's attitudes toward use of math manipulative materials. (Question 20 seemed the most easily quantifiable way to ask "How much more diversity in math manipulative materials do you wish?") Prior to distribution, the questionnaire was reviewed by two area elementary school teachers, four mathematics educators and an urban math coordinator for "content validity". Several modifications were made as a result of this review.

Questionnaires were sent to the principal of each North Dakota elementary school with level one accreditation, which included approximately 1000 teachers. (One level 1 district was omitted due to shortage of questionnaires.) Then random selections were made of accreditation level 2 and level 3 schools until 500 teachers at each level would be surveyed. The principals were asked to distribute, collect and return the surveys. A business reply envelope was provided. One hundred forty-seven (147) schools were supplied with a total of 2100 questionnaires. One hundred sixteen schools returned a total of 989 completed questionnaires, for return percentages of 79% of surveyed schools and 47% of questionnaires. The mailing was based on the 1976-1977 North Dakota Educational Directory (19).

From the questionnaire, four derived pieces of information were added in addition to the teacher responses. Three "totals" were included; a total number of math manipulative materials checked in question 9, a total number of materials sources checked in question 11, and a total number of information sources checked in question

12. An additional code was added which was the author's attempt to make a qualitative determination of materials use; the code was based on the combined number of materials checked in question 9 and the extent of use indicated in question 10. The coding was:

1 0-2 checks in 9, a little
2 3 or more checks in 9, a little
3 1-4 checks in 9, quite a bit
4 5 or more checks in 9, quite a bit
5 1-4 checks in 9, very extensively
6 5 or more checks in 9, very extensively

This coding was intended to reflect both diversity and intensity of materials used, with intensity more important than diversity.

The data were then transferred from the questionnaires to computer cards and subjected to computer analysis. All questions were tabulated, and the data were analyzed to determine if any relationships existed between use of materials and any other information that was collected.

The results of the tabulation and analysis are given in the next section. Discussion and interpretation of the results are in the succeeding section.

III. RESULTS

This section contains the tabulations of results from the questionnaire and relationships of potential interest. The section is divided into four subsections. The first three parallel the three categories of questions: teacher characteristics, use of manipulatives, and attitudes toward manipulatives. The fourth section presents correlations and relationships found among variables by the statistical analysis. For complex displays of information considered

to be of secondary interest, summary information is given in the body of the paper and a complete table is included in Appendix B. In all tables grade 7 and 8 information has been included in grade 6 due to the low sample size (6). Missing data are not included in calculations; hence totals may vary.

1. Teacher Characteristics

Responses to question 1-8, 15, 19, and 21 are presented in tabular form. Tables with an asterisk (*) by the table number have comparable tables with grade level breakdowns in Appendix B. The tables are all self-explanatory, so no further discussion is given.

Table 1*

YEARS OF EXPERIENCE TEACHING ELEMENTARY SCHOOL

	Number	Percent
0-1 years	62	6.3
2-3 years	117	11.9
4-5 years	153	15.6
6 or more years	649	66.2

Table 2

GRADE LEVEL TAUGHT

	Number	Percent
Kindergarten	46	4.8
Grade 1	203	21.2
Grade 2	159	16.6
Grade 3	138	14.4
Grade 4	157	16.4
Grade 5	143	14.9
Grade 6	111	11.7

Table 3

DEGREE LEVEL

	Number	Percent
Less than Bachelors	30	3.0
Bachelors	296	30.1
Bachelors +	510	51.8
Masters	142	14.4
Other	6	0.6

Table 4

DEGREE SOURCE

	Number	Percent
Dickinson State College	73	7.4
UND - Ellendale	12	1.2
Jamestown College	16	1.6
Mary College	37	3.8
Mayville State College	74	7.5
Minot State College	154	15.6
North Dakota State University	3	0.3
University of North Dakota	157	15.9
Valley City State College	114	11.6
Other (includes more than one of the above)	346	35.1

Table 5*

ATTITUDE TOWARD TEACHING MATHEMATICS

	Number	Percent
One of favorite subjects	593	60.8
Neutral	312	32.0
One of least favorite subjects	70	7.2

Table 6*

TIME SPENT ON TEACHING MATHEMATICS

	Number	Percent
0-2 hours/week	73	7.5
2-4 hours/week	269	27.7
4-6 hours/week	548	56.5
More than 6 hours/week	80	8.2

Table 7*

CLASSROOM ORGANIZATION (Categories overlap)

	Number	Percent
Self-contained	780	79.3
Team taught	115	11.7
Departmentalized	72	7.3
Special Education	47	4.8
Individualized	283	28.8
Learning Centers	240	24.4
Other	38	3.9

Table 8*

SATISFACTION WITH TEXTBOOK

	Number	Percent
Very satisfied	264	28.1
Somewhat satisfied	415	44.2
Somewhat dissatisfied	163	17.4
Very dissatisfied	96	10.2

Table 9

PRESENT KNOWLEDGE OF USE OF MATH MANIPULATIVE MATERIALS

	Number	Percent
Inadequate	347	37.2
Adequate	573	61.5
Extensive	12	1.3

Table 10

RATING OF UNDERGRADUATE METHODS COURSES WITH RESPECT TO MATH MANIPULATIVE MATERIALS

	Number	Percent
Rated outstanding	24	2.6
Rated good	251	27.2
Rated fair	359	38.9
Rated poor	289	31.3

Ninety-nine percent of the respondents to question 15 reported that other teachers in their school use math manipulative materials.

2. Use of Math Manipulative Materials

The data in Table 11 shows the summary of usage, by grade level, for each of the math manipulative materials surveyed. The percentage of teachers at each grade level using each manipulative is given. For example, 17% of third grade teachers and 23% of all teachers indicated that they use geoboards.

Metric materials have the greatest use, with high incidence of use in every grade level above kindergarten. Counting chips and bundles of sticks have the next highest use, with extensive incidence of use in the primary grades. The "other" category consisted

mostly of the abacus and number lines.

Table 11

PERCENT OF TEACHERS BY GRADE LEVEL AND TOTAL
USING MATH MANIPULATIVE MATERIALS

Manipulative	Total	K	1	2	3	4	5	6
Multibase Arithmetic Blocks	9	0	15	13	7	6	8	7
Cuisenaire Rods	20	37	29	26	17	12	15	13
Metric Materials	72	17	67	72	78	71	80	86
Geometric Construction Material	39	33	38	36	33	39	43	50
Attribute Materials	21	52	30	24	18	12	11	19
Bundles of Sticks	44	48	85	75	44	22	8	5
Fraction discs	37	4	22	41	37	49	47	46
Fraction bars	17	0	7	10	14	31	24	32
Geoboards	23	24	24	24	17	24	20	27
Tangrams	28	17	28	29	28	27	29	38
Counting Chips	45	83	80	69	45	19	10	9
Unifix Materials	2	2	3	1	2	1	1	1
Math Balance	19	22	25	21	17	15	15	16
Calculators	22	4	14	17	25	26	27	40
Other	10	17	15	10	13	9	4	7

The data in Table 12 shows the number of math manipulative materials being used by grade level. Numbers are grouped by two, and the figures are percentages of the teachers at any grade level. For example, 9% of the kindergarten teachers are using 0-1 manipulatives, while 11% of all teachers surveyed are using 0-1 manipulatives.

The data in Table 13 indicates the extent of use of math manipulative materials by grade level using the code detailed in section II. The code, 1-6, combines the total number of manipulatives used with the extent of use indicated in question 10, giving priority to extent of use over number of materials. Roughly speaking, the higher the number, the more extensive the use of more manipulatives.

Table 12

PERCENT OF MATH MANIPULATIVE MATERIALS USED
BY GRADE LEVEL AND TOTAL

Number Used	K	1	2	3	4	5	6	Total
0-1	9	3	5	11	19	20	11	11
2-3	43	30	35	35	31	39	38	35
4-5	35	31	23	32	32	26	25	29
6-7	9	23	26	17	10	8	20	17
8-9	2	8	7	3	8	4	4	5
10-11	2	3	3	1	0	2	2	2
12-13	0	2	1	1	0	1	0	1

All figures are percentages of teachers at a grade level who are assigned the respective code.

Table 13

PERCENT OF MATH MANIPULATIVE MATERIAL USE
BY GRADE LEVEL AND TOTAL

Use Code	K	1	2	3	4	5	6	Total
1 (least use)	20	7	12	21	28	32	24	20
2	6	19	24	36	31	33	39	28
3	35	28	22	21	19	21	13	22
4	11	32	34	20	22	11	22	23
5	17	3	1	1	0	1	0	2
6 (most use)	11	11	7	1	0	2	2	5

Almost half (48%) of the respondents indicated they use math manipulative materials only "a little" (codes 1 and 2), with 7% indicating extensive use of manipulatives. Manipulative use is highest at lower grade levels, with extensive use indicated by 28% of kindergarten teachers and 14% of first grade teachers.

Table 14 and 15 display sources of manipulatives and sources

of information about manipulatives indicated by respondents. Categories overlap in each table, so percentages total more than 100. Note that any one category need apply to only part of the math manipulative materials a teacher uses.

Table 14

SOURCES OF MATH MANIPULATIVE MATERIALS

Source	Percentage
Commercial	78
Teacher/student made	55
Parent/volunteer made	5
At school when teacher came	40
Owned by teacher	45
Obtained by school at teacher's request	36

Table 15

SOURCES OF INFORMATION ABOUT MATH MANIPULATIVE MATERIALS

Source	Percentage
Undergraduate classes	53
Graduate classes	31
Inservice classes	50
From other teachers	56
From salespersons	8
From professional reading	40
Other	6

Reference books are used by 30% of the teachers using math manipulative materials.

3. Attitudes Toward Manipulatives

There is a general consensus among the surveyed teachers that

use of math manipulative materials is beneficial to students' learning, and that they are more beneficial to students who have the most difficulty. Table 16 displays responses to the questions "In your opinion, do fast (average, slow) learners learn more or less math with math manipulative materials than without?"

Table 16

OPINIONS REGARDING LEARNING MATH BY USING MATH MANIPULATIVE MATERIALS

Learner	Amount Learned		
	More	About Same	Less
Fast learner	41%	53%	6%
Average learner	77%	22%	1%
Slow learner	94%	5%	1%

Table 17 categorizes the responses to question 14, "In your opinion, at what grade level are math manipulative materials no longer needed?" The 38% "no/other response" was divided somewhat evenly between no response and some other response, generally "depends on the student" or some equivalent response.

Table 17

OPINIONS REGARDING GRADE LEVEL AT WHICH MATH MANIPULATIVE MATERIALS ARE NO LONGER NEEDED

Grade Level	Percent
Grades K-6	10
Grades 7-9	8
Grades 10-12	4
"Always needed"	40
No/Other response	38

Table 18 displays the responses to the question regarding what would constitute an adequate budget for math manipulative materials.

Table 18

DESIRED BUDGET FOR MATH MANIPULATIVE MATERIALS

Budget	Percentage of Teachers
$10-50	46
$50-100	39
$100-300	14
Over $300	1

4. Relationships Among Variables

The section above deals with the first of the aims of this study; it categorizes what materials are being used and, to some degree, indicates the extent of their use. The data presented in this section attempts to deal with the more difficult question of "what characterizes teachers who use the materials and what differentiates them from other teachers?"

The primary tool used in attempting to answer this question was the comparison, by computer, of the code explained in Section II with each of the other sets of data. This code was used in preference to the raw data of "total number of materials used" alone or "extent of use" alone since it is believed the combination is the most important single factor. Results would not have differed greatly had either of the two other measures of use been used, since the code is based on them and thus correlates highly with both measures. This is confirmed by the very high correlation of the code with extent of use ($r = .93$) and the high correlation of the code with total

number of manipulative materials used (r = .64)*. Hence very similar results would have been obtained using either single measure as an indicator of manipulative use. When different results are indicated, they are noted.

No strong correlations were found between use of math manipulative materials and any of the data obtained. However, given the diverse nature of classrooms and teachers, it would be very surprising

*A note on the measures of correlation may be in order. The data were processed by using the Crosstabs subprogram of the Statistical Package for the Social Sciences, SPSS (Nie, 17). This program provides several measures of relationship of variables; this analysis used Cramer's V, the Contingency Coefficient, Tau C, Gamma, Sommer's D (symmetric) and Pearson's r. Each provides a somewhat different measure of relationship and expresses it as a decimal coefficient, generally between 0 and 1 or -1 and +1. Coefficients near zero indicate no relationship between variables (at least of the type the particular correlation measures); coefficients near ±1 indicate a very strong relationship; coefficients near ±.3, say, indicate a weak relationship. Due to the large sample size, it was quite possible to obtain statistical significance for coefficients that were of little meaning. For example, values of r larger than .08 were generally significant at the .01 level, while values of r larger than .11 were generally significant at the .0001 level. However, neither value indicates a relationship strong enough to be meaningful. In the text that follows, selected values of the relational measures are given; complete tables are exhibited in Appendix C.

if any were found. The weak correlations that were found were instructive, as were lack of correlations in several instances.

Years of experience, degree level, attitude toward teaching math, time spent on teaching math and satisfaction with the text had no apparent relationship to use of manipulatives. Grade level showed a notable negative correlation to manipulative use ($r = -.30$); i.e. the lower grade levels tend to make more extensive use of math manipulatives. This is a confirmation of what was apparent from Table 13 shown on page 12. The complete table of relationship measures is given in Appendix C, Table 32.

Classroom organization also has some relationship to manipulative use. Classes with learning centers were more likely to use manipulatives ($r = .30$), as were classes that were described as individualized ($r = .21$). Relationships between manipulative use and classrooms described as self-contained, team taught, departmentalized, special education or other were very low. Note that classes may have been described by several of the above terms, while comparisons were made to each descriptor individually. Thus, for example, a classroom described as self-contained with learning centers would have a higher probability of using manipulatives because of the "learning center" description, but no information about manipulative use would be gained by the "self-contained" descriptor. The relationship measures for classroom organization are given as Table 27, Appendix C.

Several interesting relationships occur with source of manipulatives and source of information concerning manipulatives. Tables 19 and 20 show the contingency coefficient C (which measures rela-

tionship without indicating kind of relationship) and Pearson's r (which measures linear relationship). Complete relational tables are given in Appendix C, Tables 28 and 29.

Table 19

RELATIONSHIP BETWEEN SOURCE OF MANIPULATIVES AND USE OF MANIPULATIVES

Source	Correlations C	r
Commercial	.16	.13
Teacher/student made	.29	.25
Parent/volunteer made	.16	.13
At school when I came	.16	.15
My own	.33	.33
Obtained by school, my request	.31	.29
Total number of sources	.47	.44

This indicates that teachers are more likely to use materials that they own, that they constructed, or that they requested. The strongest relationship to use, however, is having a variety of sources.

Table 20

RELATIONSHIP BETWEEN SOURCE OF INFORMATION ABOUT MANIPULATIVES AND USE OF MANIPULATIVES

Source of Information	Correlations C	r
Undergraduate classes	.19	.18
Graduate classes	.21	.17
Inservice classes	.22	.19
From other teachers	.19	.15
From salespersons	.16	.13
From professional reading	.27	.25
Other	.12	.08
Total number of sources	.46	.39

The highest relationship to manipulative use is with professional reading, with inservice, graduate and undergraduate classes having a somewhat lower and about equal relationship. Again, a variety of sources is much more important than any particular source.

There was a much higher relationship between use of math manipulative materials and the belief that fast or average learners benefit by manipulative use than do the belief that slow learners benefif (r = .23, .24, .08 respectively). This is probably because the belief that slow learners benefit from use of manipulatives is so high that this does not serve to differentiate teaching practice (see Table 16, page 14). The data in Table 30, Appendix C, give the complete set of relationships.

The remaining six variables, use of reference books, grade level at which manipulatives no longer needed, other teachers using manipulatives, knowledge of manipulative use, opinion regarding adequate manipulative budget, and quality of undergraduate course, produced only two relationships of notable strength: use of reference books (r = .26) and knowledge of manipulative use (r = .25). This cannot be considered particularly enlightening. A complete table of relationship measures for these six variables is given as Table 31, Appendix C.

IV. DISCUSSION

Two limitations of the survey results must first be discussed. First, teachers who are making some use of math manipulative materials are more likely to answer a survey regarding their use than teachers making no such use. Hence it is probable that all of the

percentages regarding manipulative use are somewhat overstated; the degree of error (if one exists) is difficult to estimate. Second, interpretations of terms may differ from person to person and group to group. Thus a necessary compromise in attempting to have the questionnaire both simple and clear may make interpretation difficult. This is possible in the area regarding extent of use of manipulatives. It was the perception of the author and several other math educators, all of whom have regular contact with area classrooms, that math manipulative use was quite limited; the questionnaire indicates otherwise. It is possible the perception was in error, or it is possible that a teacher's interpretation of "quite a bit" differs from that of the math educator's interpretation. Had that been anticipated, the question regarding extent of use might possibly have been stated to leave less room for interpretation. However, the cost may well have been more complexity and a lower return, with possibly no better results. At the least, the survey provides a good indication of what materials exist in North Dakota elementary school classrooms, and some indication of their use.

Clearly, there is a considerable number of materials in the schools. Ninety percent of teachers responding use 2 or more manipulatives, and over 50% use 4 or more manipulatives. Metric materials are used in over 70% of classrooms, and simple place value materials (bundles, chips) are used in over 75% of first and second grades. Geometric construction materials and fraction discs are used in a fairly high number of classrooms.

Extent of use is not particularly high. About half (48%)

indicated only "a little" use, only 7% use manipulatives "extensively". It is possible to conjucture that this is because two-thirds of the teachers surveyed have taught six or more years. It is unlikely that their undergraduate preparation had any emphasis on either developmental theory or manipulative use. This is also reflected in the over 70% of respondents that rated their undergraduate methods courses "fair" or "poor" with regard to math manipulative materials. However, there was no relationship found between years of experience and manipulative use. Experienced teachers, apparently, are neither more nor less likely to use manipulatives than inexperienced teachers. Surprisingly, there was also no relationship with attitude towards teaching math, time spent on teaching math, or satisfaction with the text. The correlation between use of manipulatives and grade level is lower when only number of materials is considered (see Table 26). This indicates that intensity of use, rather than diversity, is greater at lower grade levels.

The relationship between manipulative use and learning centers is not surprising; manipulative materials lend themselves to learning center settings, particularly if there are insufficient materials for use by the whole class at once. It would possibly be interesting to investigate whether desire to use manipulatives led to creation of learning centers or vice versa. Much the same comments could be made about the (weaker) relationship with individualized classrooms, as varying modes of learning could well be an aspect of individualizing. It was somewhat disappointing, from the author's point of view, that there was no relationship between

materials use and special education settings. Both developmental theory and the respondent's replies to the question concerning use of materials by slow learners would indicate that increased use of manipulatives would be appropriate for special education students. The survey indicates that this is not the case.

Sources, both of the manipulatives themselves and of information about them, provide some interesting relationships (see Tables 28 and 29). Those sources of materials that indicated personal involvement by the teacher (teacher owned, teacher/student made, teacher requested) showed the highest correlations with use of materials. Undergraduate, graduate and inservice classes all showed some relationship to materials, but all were weaker relationships than professional reading. This may be an indication that the teachers using math manipulatives are the more highly motivated teachers; they "keep up" professionally through journals, graduate and inservice classes. In both categories of sources, Dienes "multiple embodiment" principle seems to obtain, i.e., the more sources one has, the higher the likelihood of using the materials/information. Conversely, this may simply indicate that the teachers who desire to use manipulatives seek out sources of materials and information.

The indicators of opinion regarding how learning is affected by use of math manipulatives leaves hope that use will continue to grow (see Tables 16, 30). Almost all teachers (94%) believe slow learners learn more through use of math manipulative materials, and a substantial majority (77%) believe average learners learn more. This, with the rather low actual use indicated by the survey, would

seem to indicate a rather large potential market for growth in this area. This may be contradicted, however, by the data regarding current knowledge and adequate budget. In spite of the current rather low use of materials, almost two-thirds (63%) of the teachers consider their present knowledge of use of math manipulative materials at least adequate, and 85% would consider a budget of $100 or less as adequate for math manipulatives. The latter information is of particular significance, since a brief perusal of some catalogs indicates that it would cost over $800 to get a classroom set of each manipulative listed, and over $170 to obtain enough of each manipulative for one student or one small group of students. This may be interpreted in several ways. It may be that teachers really don't want higher use of materials; it may be that budgets for such materials have been low or nonexistent for so long that even $50-100 sounded like too much to hope for; it may be that teachers have never priced the materials; it may simply be that teachers would first wish to make more extensive use of materials already in the classroom.

V. RECOMMENDATIONS

The recommendations that follow are based on two assumptions: that increased intensity and diversity in use of math manipulative materials is good (see Section I), and that the relationships found, although weak, are sufficiently meaningful to act upon.

1. The fastest way to increase intensity of manipulative use is to increase use of manipulatives already in the classroom. This would indicate that, for the intermediate grades, the initial focus

of training would be on metric materials, geometry materials, fraction materials and calculators, and for the primary grades, measurement, numeration and place value materials.

2. Since personal involvement in source of materials is related to their use, workshops that make materials and activities appear appropriate. For preservice classes, math manipulative materials packages may be appropriate as a replacement or supplement to the normal textbook.

3. Professional reading was the source of information most highly related to manipulative use. The Arithmetic Teacher, a publication of the National Council of Teachers of Mathematics, already devotes considerable space to manipulative materials and their uses. However, this journal is not widely read by classroom teachers. It appears appropriate to attempt to diversify such information in journals more widely read by teachers, as well as making The Arithmetic Teacher more widely known.

4. There is a positive correlation between use of manipulatives and use of learning centers. It would seem appropriate to provide more support for teachers who wish to make math learning centers, perhaps in the forms of models, content and operation suggestions, activities, and so forth. These could be modeled and discussed in both preservice and inservice courses, in workshops and in journal articles.

The data in this article are, of course, far from definitive and complete. Several further studies are suggested.

5. Further information would be useful which would better define "extent of use" of math manipulative materials. It may well

be necessary to use an interview, rather than a questionnaire, to meaningfully determine this. An interview process may also be useful in better determining why manipulatives are being used by those using them, why they are not in the other cases, and what kind of support each group could use.

While many more questions for study could be raised, the author believes these are the most important ones. It is hoped this study was at least a beginning.

APPENDIX A

QUESTIONNAIRE AND TRANSMITTAL LETTER

The University of North Dakota

GRAND FORKS 58202

The Center for Teaching and Learning

April 12, 1977

Dear

The enclosed questionnaires are designed to provide information needed to plan better pre and inservice mathematics programs. Would you kindly distribute, collect and return the questionnaires for me? They will take five minutes or less for your teachers to complete, and are entirely anonymous with respect to both teacher and school identity. A return envelope is included for the completed questionnaires.

I would greatly appreciate it if they could be returned by April 29. Please distribute them to teachers of kindergarten through grade six who teach math. I have attempted to send an adequate supply for this by use of the North Dakota Educational Directory; if I sent an inadequate supply, please distribute them evenly among the grades.

The survey is being supported by the University of North Dakota Bureau of Educational Research and Services. Your school will be provided a copy of the survey results. Your assistance is appreciated.

Sincerely,

Ron Kutz

Ronald E. Kutz

Enclosures

— An Equal Opportunity Employer —

The following questionnaire will take about five minutes of your time to complete. The information will be used to plan inservice and preservice mathematics programs. I would greatly appreciate it if you could complete the questionnaire within three days and return it to your principal. The study is being supported by the North Dakota Bureau of Educational Research and Services. A copy of the results will be provided for your school. Thank you for your cooperation. Ron Kutz

1. How many years have you taught elementary school? ☐ 0-1 ☐ 2-3 ☐ 4-5 ☐ 6/more

2. At what grade level are you now teaching? _____

3. What is your highest college degree? ☐ Less than Bachelors ☐ Bachelors ☐ Bachelors + ☐ Masters ☐ Other _____

4. Where did you receive your course work for elementary certification? ☐ Dickinson ☐ Ellendale ☐ Jamestown ☐ Mary College ☐ Mayville ☐ Minot ☐ NDSU ☐ UND ☐ Valley City ☐ Other _____

5. Do you consider math: ☐ One of your favorite subjects ☐ One of your least favorite subjects ☐ Neutral

6. About how much total time do you devote to math teaching each week: ☐ 0-2 hrs. ☐ 2-4 hrs. ☐ 4-6 hrs. ☐ More than 6 hrs.

7. Check all that apply. Is your class: ☐ Self-contained ☐ Team-taught ☐ Departmentalized ☐ Special Ed. ☐ Individualized ☐ Learning Centers ☐ Other _____

8. How satisfied are you with your present math text? ☐ Very satisfied ☐ Somewhat satisfied ☐ Somewhat dissatisfied ☐ Very dissatisfied

For the remainder of this questionnaire, math manipulative materials refer to those concrete objects which, when handled or operated by the pupil and the teacher, provide the pupil with an opportunity to attain specific mathematical objectives. All questions relate only to math materials.

9. Check each of the following math manipulative materials you have used this past year.

- ☐ Multibase arithmetic blocks
- ☐ Cuisenaire Rods
- ☐ Metric measuring materials
- ☐ Geometric construction material
- ☐ Attribute materials (A-blocks, people pieces, etc.)
- ☐ Bundles of sticks
- ☐ Fraction discs
- ☐ Fraction bars
- ☐ Geoboards
- ☐ Tangrams
- ☐ Counting chips
- ☐ Unifix materials
- ☐ Math balance
- ☐ Calculators
- ☐ Other _____
- ☐ Other _____
- ☐ Other _____

*If none were checked, skip 10 through 14 and go to question 15.

10. Taken collectively, did you use these materials: ☐ A little ☐ Quite a bit ☐ Very extensively

11. Check all that apply. Were these materials: ☐ Commercially made ☐ Teacher/Student made ☐ Parent/Volunteer made ☐ At the school when I came ☐ My own ☐ Obtained by the school at my request

12. Check all that apply. Did you learn about these materials:
☐ In undergraduate classes ☐ In graduate classes ☐ In inservice classes
☐ From other teachers ☐ From salespersons ☐ From professional reading
☐ Other _____

13. Do you have any reference books on math manipulative materials that you use? ☐ Yes ☐ No If so, what? _____

14. In your opinion, at what grade level are math manipulative materials no longer needed? _____

15. Are other teachers in your school using math manipulative materials? ☐ Yes ☐ No

16. In your opinion, do fast learners learn more or less math with math manipulative materials than without? ☐ More ☐ Less ☐ About the same

17. In your opinion, do average learners learn more or less math with math manipulative materials than without? ☐ More ☐ Less ☐ About the same

18. In your opinion, do slow learners learn more or less math with math manipulative materials than without? ☐ More ☐ Less ☐ About the same

19. Would you characterize your present knowledge regarding use of math manipulative materials as: ☐ Inadequate ☐ Adequate ☐ Extensive

20. With regard to math manipulative materials, what would you consider an adequate budget for your class math manipulative materials for next year?
☐ $10-50 ☐ $50-100 ☐ $100-300 ☐ Over $300

21. With regard to math manipulative materials, would you characterize your undergraduate methods courses as: ☐ Poor ☐ Fair ☐ Good ☐ Outstanding

APPENDIX B

TABLES OF VARIOUS DATA BY GRADE LEVEL

Table 21

YEARS OF EXPERIENCE TEACHING ELEMENTARY SCHOOL BY GRADE LEVEL AND TOTAL

Years Experience	Grade Level* K	1	2	3	4	5	6	Total
0-1	6 (14)	15 (7)	8 (5)	9 (6)	8 (5)	7 (5)	4 (3)	57 (6)
2-3	8 (18)	28 (14)	19 (12)	9 (7)	21 (14)	11 (8)	12 (11)	110 (12)
4-5	7 (16)	33 (16)	26 (16)	23 (17)	24 (15)	19 (13)	16 (15)	148 (15)
6 or more	23 (52)	126 (63)	106 (67)	97 (70)	103 (66)	106 (74)	75 (71)	639 (67)

Table 22

ATTITUDE TOWARDS TEACHING MATHEMATICS BY GRADE LEVEL AND TOTAL

	Grade Level* K	1	2	3	4	5	6	Total
One of favorite subjects	11 (24)	95 (47)	83 (54)	84 (61)	107 (69)	113 (79)	84 (82)	581 (61)
Neutral	27 (60)	86 (43)	58 (37)	46 (33)	40 (26)	28 (19)	17 (16)	304 (32)
One of least favorite subjects	7 (16)	20 (10)	14 (9)	8 (6)	8 (5)	3 (2)	2 (2)	62 (7)

*This footnote applies to Tables 21, 22, 23, 24, 25.

1. Number of respondents given, with percentage of that grade level in ( ).
2. The small discrepancy between this table and the comparable table in Section III occurs because some respondents omitted grade level.

Table 23

TIME SPENT ON TEACHING MATHEMATICS BY GRADE LEVEL AND TOTAL

Time Spent	Grade Level* K	1	2	3	4	5	6	Total
0-2 hrs./week	23 (52)	19 (10)	11 (7)	2 (2)	0 (0)	8 (6)	1 (1)	68 (7)
2-4 hrs./week	15 (34)	101 (51)	58 (37)	33 (24)	25 (16)	18 (13)	11 (10)	262 (28)
4-6 hrs./week	5 (12)	69 (35)	84 (54)	91 (67)	122 (78)	96 (68)	75 (71)	543 (57)
More than 6 hrs./week	1 (2)	9 (4)	3 (2)	10 (7)	10 (6)	18 (13)	19 (18)	74 (8)

Table 24

CLASSROOM ORGANIZATION BY GRADE LEVEL AND TOTAL (Categories overlap)

	Grade Level* K	1	2	3	4	5	6	Total
Self-contained	39 (85)	171 (84)	139 (89)	115 (83)	111 (71)	111 (77)	84 (79)	771 (81)
Team taught	7 (15)	18 (9)	13 (8)	17 (12)	27 (17)	21 (15)	7 (7)	111 (12)
Departmentalized	2 (4)	4 (2)	2 (1)	2 (1)	11 (7)	22 (15)	24 (23)	71 (7)
Special Education	4 (9)	8 (4)	4 (3)	2 (1)	4 (3)	1 (1)	2 (2)	26 (3)
Individualized	20 (44)	64 (32)	41 (26)	36 (26)	51 (33)	34 (24)	24 (23)	271 (28)
Learning centers	21 (46)	62 (31)	42 (27)	42 (30)	31 (20)	20 (14)	16 (15)	235 (25)
Other	3 (7)	10 (5)	0 (0)	8 (6)	4 (3)	4 (3)	5 (5)	35 (4)

Table 25

SATISFACTION WITH TEXTBOOK BY GRADE LEVEL AND TOTAL

	Grade Level*							
	K	1	2	3	4	5	6	Total
Very satisfied	8 (26)	63 (33)	54 (34)	28 (21)	34 (22)	39 (28)	30 (29)	258 (28)
Somewhat satisfied	16 (51)	86 (45)	68 (43)	77 (57)	69 (44)	49 (35)	43 (41)	410 (45)
Very dissatisfied	4 (13)	31 (16)	26 (17)	16 (12)	32 (20)	31 (23)	19 (18)	159 (17)
Somewhat dissatisfied	3 (10)	12 (6)	10 (6)	15 (11)	21 (14)	19 (14)	12 (12)	94 (10)

APPENDIX C

TABLES OF RELATIONSHIPS

Table 26

RELATIONSHIPS BETWEEN USE OF MATH MANIPULATIVE MATERIALS AND SELECTED TEACHER CHARACTERISTICS

Teacher Characteristic	Measures of Correspondence* V	C	Tc	γ	D	r
Years experience	.07	.12	.02	.04	.02	.01
Grade level	.21	.46	-.24	-.30	-.24	-.30
	(.13)	(.35)	(-.12)	(-.14)	(-.12)	(-.07)
Degree level	.08	.17	.07	.12	.08	.09
Attitude toward math	.10	.18	-.06	-.11	-.07	-.07
Time spent on math	.12	.20	-.04	-.07	-.05	-.04
Satisfaction with text	.08	.14	.01	.01	.01	-.01

Table 27

RELATIONSHIPS BETWEEN USE OF MATH MANIPULATIVE MATERIALS AND CLASSROOM ORGANIZATION

Classroom Organization	Measures of Correspondence* V	C	Tc	γ	D	r
Self-contained	.06	.09	.01	.02	.01	.00
Team taught	.11	.11	.03	.10	.03	.05
Departmentalized	.07	.07	-.04	-.17	-.04	-.06
Special Education	.13	.13	.03	.17	.03	.06
Individualized	.24	.23	.20	.31	.17	.21
Learning Centers	.32	.31	.29	.49	.26	.30
Other	.05	.05	.01	.06	.01	.02

*This footnote applies to Tables 26, 27, 28, 29, 30, 31.

1. V = Cramer's V, C = contingency coefficient, Tc = Kendall's tau C, γ = gamma, D = Somer's D (Symmetric), r = Pearson's r, see (17) for an explanation.
2. For all measures, favorable responses were coded positive (e.g. math one of favorite subjects was coded highest)
3. All relationships are measures of correspondence with the code 1-6 described in Section II. Where this differs substantially from the correspondence with total number of materials used, the later relationships are given in ( ) below the first relationship.

Table 28

RELATIONSHIPS BETWEEN USE OF MATH MANIPULATIVE MATERIALS AND SOURCES OF MANIPULATIVES

Sources of Materials	Measures of Correspondence* V	C	Tc	γ	D	r
Commercial	.16	.16	.13	.24	.12	.13
Teacher/student made	.31	.29	.27	.35	.21	.25
Parent/volunteer made	.16 (.23)	.16 (.23)	.06 (.07)	.44 (.45)	.07 (.08)	.13 (.18)
At school when teacher came	.16	.16	.17	.23	.13	.15
Teacher owned	.35	.33	.37	.47	.29	.33
Obtained by school, teacher request	.33	.31	.33	.45	.27	.29
Total number of sources	.22	.47	.34	.47	.37	.44

Table 29

RELATIONSHIPS BETWEEN USE OF MATH MANIPULATIVE MATERIALS AND SOURCES OF INFORMATION

Sources of Information	Measures of Correspondence* V	C	Tc	γ	D	r
Undergraduate classes	.20	.19	.21	.26	.16	.18
Graduate classes	.21 (.27)	.21 (.26)	.19 (.25)	.28 (.34)	.15 (.20)	.17 (.24)
Inservice classes	.22	.22	.22	.28	.17	.19
Other teachers	.19	.19	.18	.23	.14	.15
Salespersons	.16	.16	.07	.30	.07	.13
Professional reading	.28	.27	.29	.38	.23	.25
Other	.11	.12	.05	.26	.05	.08

Table 30

RELATIONSHIPS BETWEEN USE OF MATH MANIPULATIVE MATERIALS AND ATTITUDE TOWARD MANIPULATIVES

Attitude regarding	Measures of Correspondence* V	C	Tc	γ	D	r
Fast learners	.17	.24	.20	.31	.20	.23
	(.16)	(.22)	(.15)	(.21)	(.14)	(.09)
Average learners	.18	.26	.17	.41	.20	.24
	(.18)	(.25)	(.15)	(.32)	(.16)	(.10)
Slow learners	.08	.12	.03	.21	.04	.08

Table 31

RELATIONSHIPS BETWEEN USE OF MATH MANIPULATIVE MATERIALS AND VARIOUS OTHER FACTORS

Factor	Measures of Correspondence* V	C	Tc	γ	D	r
Use of reference books	.27	.26	.25	.37	.21	.26
Opinion of grade level manipulatives no longer needed	.12	.29	-.04	-.07	-.05	-.11
Other teachers using manipulatives	.18	.18	.03	.84	.04	.13
	(.34)	(.32)	(.03)	(.72)	(.04)	(.06)
Knowledge of manipulative use	.22	.30	.21	.37	.22	.25
	(.20)	(.27)	(.20)	(.32)	(.20)	(.03)
Opinion of adequate budget	.08	.14	.05	.08	.06	.08
Quality of undergraduate course	.16	.27	.13	.19	.14	.16

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